Recording: The broadcast is now starting. All attendees are in listen only mode.

Devin Egan: Good afternoon and welcome to today's webinar sponsored by the national renewable energy laboratory. My name is Devin Egan. We'll give folks a few more minutes to call in and log on. So, while we wait, I'll go over some logistics and then we'll get going with today's webinar. First of all, you have a few options for how you can hear today's webinar.

In the right corner of your screen, there's a box that says “Audio Mode.” This will allow you to choose whether or not you want to listen to the webinar through the computer speakers or over the telephone. As a rule, if you can listen to music on your computer, you should be able to hear the webinar. If you have questions, please use the “Questions” pane in the right hand box on your screen. There you can type in any questions you may have during the webinar which will be addressed during the question and answer segment at the end of today's presentation.

Today's presentation will be posted to the NREL website shortly after the webinar. Additionally, a recording of the webinar will be posted in a few weeks. You will receive information on where to find the video via email when it's available. And finally, you will be prompted to complete a short survey once today's webinar is completed. Please take a few minutes to submit your answers when the webinar has ended.

Moving to today's topic, we will hear from NREL's Kirstin Alberi and Yoriko Morita on the lab's color mixing white light LED technology. Kirstin Alberi is a senior scientist here at NREL. Doctor Alberi has a BS in material science and engineering from MIT in 2003 and a PhD in material science engineering from the University of California at Berkley in 2008 where she studied optical and electronic properties of highly mismatched semiconductor alloys. She came to NREL as a post-doctoral research in the silicon materials and devices group to investigate the design and performance of thin crystal and silicon solar cells fabricated on inexpensive substrate. In 2010, Kirstin joined the Solid State Spectroscopy Group to conduct basic research on the optical and electronic properties of semiconductor alloys for photovoltaic and solid state lighting application.

In 2012, Kirstin was selected by DOE's Office of Basic Science Energy scientists as one of the few elite scientists selected nationwide to participate in the DOE's early career research program for her project to explore the use of light energy to aid the growth of semiconductor film. We also have Yoriko Morita, senior licensing executive here at NREL. Doctor Morita holds a PhD in electrical engineering and an MBA from the University of Colorado as well as a BA in physics from Lawrence University. At NREL, Yoriko is responsible for technology transfer and interactions with external entities interested in working with NREL's photovoltaic building technology portfolios. She has a registered patent agent with 17 years of intellectual property, asset *[Break in audio]* prosecution and management, due diligence and negotiations experience in private industry.

Yoriko has performed research related to polarization optics and liquid crystal devices and also spent two summers at the health specific northwest laboratory in the material science department and the Research Experience for Undergraduates program. Kirstin, Yoriko – thank you for being here today. I'll now turn it over to you, Kirstin, to begin the presentation.

Kristin Alberi: Okay. Thanks Devin. So, now that Devin's gone over the logistics, I'll start talking about the technology that we're presenting here today. So, we are presenting a new device design for high efficiency amber LEDs that will enable next generation color mixing white LED technologies. And this technology was originally developed here at NREL and was advanced through collaboration with researchers at the Massachusetts Institute of Technology.

So, the primary motivation for this work is to improve lighting technologies so we can reduce energy consumption. In 2010, it was estimated that lighting accounted for something like 18 percent of all energy consumed by US buildings and in the commercial sector, this was much higher – around 26 percent. So, this amount of energy can be significantly reduced not by changing our lighting uses by simply by changing the light bulbs that we use from a technology that's decades or even a century old to newer, more efficient, solid state lighting. US Department of Energy predicts that by switching to solid state lighting over the next two decades, we can cut our lighting energy consumption almost in half, saving approximately 2700 terawatt hours and $250 billion by 2030. And this is such a large opportunity that the DOE's Office of Energy Efficiency and Renewable Energy has largely supported the development of solid state lighting by funding a number of different research projects.

Much of this support has gone into short term advancements that's allowed caused state lighting to become commercially viable but they also recognize the need for long term development of new lighting architectures with advanced performance. And so ultimately, we'd like to develop a white LED bulb with very high efficiencies and dynamic color ___. The current state of the art LED technologies work on a phosphoric converted platform and that's been incrementally improving but what we really need to do is eventually move to newer generation architectures that overcome some of the existing limitations to these phosphoric converted designs. And that's exactly what NREL's doing. We are coming up with a high efficiency amber LED that will now enable new multichip color mixing white LED architectures with improved efficiency and also, additional functionality.

To appreciate some of the aspects of color mixing approaches for general lighting purposes, it's useful to understand how broadband illumination is created from a solid state device. So, in its basic, most ideal case, a light emitting diode is essentially just a semiconductor of PN Junction in which electrons and holes that are injected electrically recombine and produce photons of a single wavelength. So, it's a monochromatic device. And in order to produce broadband illumination, we need to go one step further. The approach that's used in most commercially available products combines a blue or a UV LED with red and green phosphors that down convert some of that emission over the entire visible spectrum.

And if you tune the emission spectrum and the amount of these phosphors that are used carefully, you can come up with a nice, balanced white light. But there are a number of problems that actually limit the performance of this device. The first is that energy is lost to the down conversion process. It's called a Stokes shift and this can be up to 18 percent for light emitted from the green phosphor and about 29 percent for the red. And on top of that, if the emission spectrum of the red phosphors isn't tuned very carefully, some of this emission can actually spill over into the infrared which our eyes can't register and so it's essentially also wasted energy.

The other problem is that color tuning or dynamic color control is not very straightforward with a single chip and so now, rebalancing of the emission spectrum is difficult once the LED's is in the phosphorus stage. So, to overcome some of these problems, the next generation of solid state lighting architectures will combine a number of individual LEDs that emit over the entire visible spectrum and this type of RGB approach is already used in displays for white light generation and could also be appropriate now for general lighting purposes with a few improvements. So, the potential for RGB or RGBA architectures is quite substantial. Not only do you reduce the Stokes shift loss or eliminate it altogether but these architectures have a potentially higher color rendering index than their phosphoric converted counterparts. And on top of that, you can also achieve dynamic color control or color adjustment because each one of these LEDs could be driven individually.

A major caveat here is that each one of these LEDs also has to be high efficiency for the entire structure to be highly efficient and their mission wavelengths also have to be carefully chosen to achieve the right color balance. And this last point is pretty important because one of the greatest functions of light is the ability to render colors and as you might imagine, your abilities to render colors increases as the number of different wavelengths and the visible spectrum also increases. So, sunlight – it has a very high color rendering index because it contains all the wavelengths in the visible spectrum but it's also very energy intensive to artificially reproduce all of those wavelengths. So, RGB LEDs significantly reduce that energy consumption because they're only producing a sub-set of those wavelengths. But with the LEDs that are available right now, we lose a critical component in the amber portion of the spectrum.

And so the challenge is to create another LED – and amber LED – that will replace that component and enable RGBA solid state lighting designs with very high efficiency as well. So, how is NREL proposing to fill this gap? Well, if you look at the semiconductors that are robust enough for high efficiency light emission in the visible spectrum, you basically have two subsets. The wide banged up nitrides are the only three ___ conductor that are capable of blue emission and the potential for creating all the visible wavelengths with one alloy Indium gallium nitride – has attracted much of the research attention both academically and industrially over the past couple of decades, and so thanks to this effort, blue LEDs are now very efficient.

They're about – have a bout a 75 percent QE. But they're a material quality ___ that occur when you add more Indium into the alloy till you shift the emission wavelength to the greener amber and that drops the device performance. So, currently, green – again, LEDs are only 32 percent efficient and it's unclear when we'll really have a good grasp on tall the issues that caused this drop and find a commercially viable solution to them. So, at this point, the amber and red wavelengths are produced with phosphide based LEDs. Specifically, allows of aluminum gallium indium phosphide are used almost exclusively by industry because they can be lattice matched to a gallium arsenide substrate for very specific indium concentrations and then the emission wavelength is tuned by adjusting the aluminum to gallium ratio.

And so red LEDs made from this material are also very efficient at 64 percent EQE but again, as we add more aluminum into the material to push the emission wavelength out to the amber, the efficiency also drops. So amber LEDs are now only 11 percent efficient. They're the worst performing LEDs in this group here. Um, the good news is that we fully understand the fundamental material limitations that cause this performance drop in aluminum gallium indium phosphide and so now the challenge is to find different allow combinations or device designs that'll overcome or at least significantly reduce these problems. And that's where NREL steps in.

So, the first major loss mechanism for alum gas LEDs or for all phosphide based LEDs in general, is inner valley transfer. So, aluminum gallium indium phosphide undergoes a direct band gap to indirect bang gap transition at about a one to one aluminum to gallium ration. And within about 100 NED of this transition, electrons preferentially transfer from the direct conduction band-edges to the closest indirect conduction band minimum. And so if we consider that __ gap crosses over at about 2.23 ED and we have to account for this 100 NED offset, then the emission wavelengths are limited to greater than 582 nanometers. And this is just for low drive current. Obviously, if we increase the drive current, this offset has to be greater and the emission wavelength will be pushed to higher values.

The other major loss mechanism is electron leakage over the colliding layer of barriers and out of the light emitting active layer. So, we're already operating at the highest direct band-gap of aluminum gallium indium phosphide for the active layer and so there aren't any other lattice matched allows with even higher direct band-gaps and favorably aligned valence and conduction band edges to provide a confinement of carriers within the active layer. And this point is demonstrated by the fact that even though we can increase both the direct and indirect band-gap of aluminum gallium indium phosphide by adding more aluminum into the alloy, most of this increase comes from a drop in the valence band edge and in fact, the indirect conduction band minimum of the alloy also drops with the aluminum concentrations increases. So, if you're planning on creating a clouding layer with an alloy with a higher aluminum concentration than the active layer, you can still get preferential electron transfer into the indirect conduction band minimum of the clouding layer. And so you end up with essentially, very little ___.

And so the take home message here is that the valence and conduction band offsets matter just as much as the total band-gap offset between the active and clouding layers. And so now we have to find new or alternative ways of providing this electron confinement. So, our approach here at NREL is to move to a slightly different allow composition aluminum indium phosphide because it has the highest direct/indirect band-gap transition of any of the non-nitrade 35s. It's at about 2.32EV compared to 2.23EV in __ gap and that extra 90MEV offset makes all the difference in really suppressing inner valley transfer at amber emission wavelengths. This material also exhibits a property or behavior that is favorable for engineering in electron confinement into the device.

So, at certain growth conditions aluminum and indium atoms preferentially order along alternating 111 planes in the crystal lattice by a process known as spontaneous atomic ordering. And so the presence of these alternating ordered planes causes a change in the band structure of the ordered alloy compared to its disordered counterpart and actually pushes the direct conduction band edge downward in energy. And so now you can think of a device design in which the active layer is composed of ordered aluminum indium phosphide and the clouding layers are composed of the disordered variant of the same alloy to produce the electrons *[Break in audio]*. Our initial experimental findings suggest that the conduction band edge offset between partially ordered and fully disordered aluminum indium phosphide could be as high as 200NED which is actually a very significant amount of confinement in these types of devices. Ordering is favorable under intermediate growth temperatures of about 625 to 700 degrees C during metal organic vapor deposition and that can be suppressed at either higher or lower temperatures and also upon the addition of dopins into the materials, so that actually works quite nicely for these devices since the clouding layers are heavily doped.

The other advantage here is that the alloy composition does not need to be changed between the clouding and active layer – layer materials. So, that makes growth a little bit simpler there as well. There are a couple of barriers that have, until now, limited any serious consideration of aluminum indium phosphide or light emitting applications. The first one is that oxygen bonds very strongly to aluminum and creates defects that lower the emission efficiency of devices. But what we found is that steady improvements in reactor design and precursor purity have largely limited this problem to the point where now, people are even putting aluminum into very high *[Break in audio]*.

The other problem is the lack of a lattice matched substrate. So, direct band-gap aluminum indium phosphide has a slightly larger lattice constant that gallium arsenide and so when these layers are gown on top of the gallium arsenide's substrate, the strain that builds up them _ grows, relaxes via dislocation formation, which lowers the material quality and causes a drop in the emission efficiency. And that's one of the reasons why aluminum gallium indium phosphide is so heavily used by industry because it is lattice matched to this gallium arsenide substrate and can be grown with very high quality. But what we found – or what our colleagues at MIT have found – is that they've been able to perfect metamorphic growth of aluminum indium phosphide on gallium arsenide substrates by introducing a compositionally graded gallium indium arsenide buffer between the two that's about a micron or two thick and that allows the lattice constant to transition very gradually, controlling defect formation and largely suppressing the formation of defects within the aluminum indium phosphide LED layers. And so with this technique, we've been able to reduce the threat in dislocation in these aluminum indium phosphide LEDs to be pented up for ___ kind of the five percent of your square range, which is now adequate for high efficient light emission.

So, how well do these devices perform? Fabrication of fully optimized LED structures with all the light extraction and current spreading features that are used in commercial devices is actually pretty difficult in a small research environment. And so one way that we've been able to roughly gauge the performance of our aluminum indium phosphide LEDs is to compare them with lattice matched aluminum gallium indium phosphide and lattice matched gallium indium phosphide LED standards with the same un-optimized device structure. And the point of this comparison is to normalize for our expected efficiency losses due to these un-optimized structures against a material that we know will work well as an LED if it is optimized in the correct structure. So, in this case, lattice matched gallium indium phosphide LEDs have demonstrated absolute EQEs above 50 percent.

And so if we know that we have the same high material quality – which we do because we compare these materials against the same alloys that are used in world record, multi tension solar cells – then we can use this comparison to extrapolate the efficiency of our aluminum indium phosphide LEDs as well. So, our best devices are 20 to 40 percent as efficient as the gallium indium phosphide standard when they have emission wavelength in the range of 566 to 600 nanometers. And so now you can use this extrapolation to suggest that our aluminum indium phosphide LEDs can be up to 20 percent as efficient. And if we compare a few lattice matched aluminum gallium indium phosphide LEDs within the same short wavelength range, ours perform much, much better than those. So, considering that these state of the art, amber LEDs right now are between 10 and 11 percent efficient, our technology could double that efficiency.

And also, we still have some head room for improvement in material quality and device design. You can see right here that most of our light in many of our devices is created just underneath the front contact. So, we believe that this number could be actually even higher. So, our technology actually provides a few benefits and advantages. The benefit is that we overcome two of the most important loss mechanism in phosphide based LEDs.

By pushing the direct to indirect band-gap transition out to higher energies, we reduce the amount of inner valley transfer at amber emission wavelengths and we also come up with a way to introduce higher electron confinement into these devices, which would make them much more efficient. And even though aluminum indium phosphide is not exactly lattice matched to gallium arsenide, we've also come up with growth techniques that allow us to reduce the formation and impact of threatening dislocations. And so now we feel that our aluminum indium phosphide amber LED technology is robust enough to enable color mixing RGBA white light architectures. In terms of performance advantages – as I just mentioned, we're overcoming fundamental material limitations to amber emission from aluminum gallium indium phosphide simply by switching to a slightly different alloy composition. That allows our amber LEDs to perform much better.

In terms of manufacturing advantages, these LEDs could be fabricated in much the same way that conventional aluminum gallium indium phosphide LEDs are produced. So, they can be grown on a commercially available gallium arsenide substrate by the same metal organic chemical vapor deposition processes that are already used using very similar double heterostructure architectures. And this will allow this type of technology to be adopted commercially much, much more quickly. So now I'm gonna turn it over to Yoriko and he's gonna talk more about the commercialization opportunities.

Yoriko Morita: Thanks, Kirstin. So, with the commercialization opportunity, I'd like to discuss a number of topics. So, just as an overview, we'll start with the applications that we envisioned for this technology. I'll do a brief summary of the market opportunity, very short summary of our associate and intellectual property as well as a fairly detailed discussion of our licensing process because that's really the aim of this particular presentation. And then I'll spend a little time talking about other opportunities beyond this particular technology portfolio.

So, as far as the applications for this technology, there are number of – the big one, of course, is the one that Kirstin has been discussing so far which is solid state lighting. So, there's conventional LED based solid state lamps in for general lighting, also for things like industrial lighting such as in traffic signals, residential lighting, automotive applications and other consumer electronics. Also, because we're the fundamental technology that enables these amber LED applications, also have the – the fundamental technology is really much more fundamental the semiconductor processing in and of itself. We believe that this technology can be applied, also, to photable ___ where we do have a lot of expertise at NREL as well as for things like lasers that require the combination of different semiconductor materials in order to enable those devices to function. Now, for the market opportunity, we believe that this is a very large market opportunity.

As an example of some of the numbers that have been calculated for this market, 87 percent of the solid state lighting market in 2012 was for back lighting and general lighting and we do believe quite a bit of high growth expected. The solid state lighting market is very large, particularly in the Asia-Pacific. So, half of this 87 percent of the solid state lighting market was in the Asia-Pacific region and also spread globally quite a bit – about a quarter of it in North America as well as quite a bit in Europe and the other brick countries. Now with the LED lighting, we believe, in general, there have been studies that have calculated that the LED lighting market will be over $35 billion by 2014 with 47.8 percent growth expected over this calendar year – 2013. For packaged LEDs such as luminaires and replacement bulbs, for example, the market doubled between 2011 and 2012 form approximately $1.6 billion up to $3.2 billion and various market studies indicate that LED general lighting market is expected to continue on a rapid growth curve through at least 2020.

And that growth has a lot to do with a variety of factors including the phase out of incandescent lighting that is being encouraged by US and other several high energy consumption countries. Now, Europe actually has been leading the way in that effort and USA is pretty close second. An increased commercialization investment in RNV in solid state lighting technologies, particularly by governments. Kirstin mentioned the DOE effort earlier as well as corporations who have recognized the technology and market opportunities as well as the potential energy efficient implications of these technical advances. Another factor driving this market growth has to do with a large drop in prices of LED fixtures and replacement bulbs leading to higher adoption in residential, commercial and outdoor applications.

And so we expect – even there are *[Break in audio]* studies that expect this market to grow by almost 19 percent SAGR through 2018, reaching almost 57 billion by 2018. Now, we believe that amber LEDs are – can present a game changer in this market because of the enablement of the direct combination of LEDs in order to produce white light, as Kirstin has described earlier. So, LED lighting itself is a huge and high growth market with a large trend towards energy efficient solid state lighting as – and they've also helped by legislation banning incandescent worldwide. And NREL's technology can enable a better LED based white light solid state lighting solution which is more efficient and easy to manufacture at a large scale because we're based on existing manufacturing technologies already prevalent in the LED industry as well as enabling dynamic color control, which was previously not possible with existing technologies. So, a brief discussion of intellectual property associated with this – the NREL technology portfolio.

We have a couple of records of invention that have been submitted surrounding this technology, both of which are pending as patent applications. There are two families – one, the 0936, which has a US patent application currently pending and another one – ROI1064 – which has patent applications pending in the US, Canada, Japan and Europe. Now, more details regarding these specific patent applications can be found at the website that's shown on your screen. Now, for a detailed discussion of the licensing process at NREL that we envision for this technology.

So, the role of my office - the Technology Transfer Office at NREL – is to manage commercialization of the IT portfolio.

We deal with third parties to negotiate patent and software licensing agreements. We also negotiate terms for technology partnership agreements such as the CREDA, which is Cooperative Research and Development Agreement, WFO – which is the Work For Others, TSA – the Technical Services Agreement. Details regarding each of these partnership mechanisms can also be found on the NREL transfer website. We'll put that up on the screen a little bit later. We also try to encourage innovation and entrepreneurship both on the sides of our technologists at NREL as well as in collaboration with outside entities.

And we also have a mechanism to provide commercialization assistance in appropriate circumstances. Now, the NREL licensing agreement process envisioned for this technology portfolio starts with this webcast. So, we are starting on December 10th with this technology briefing webcast. We anticipate following this up with one on one discussions. It will be one on one discussions with myself and any party interested in potentially commercializing this technology.

We are putting a time limit on these one on one discussions so between December 12th and January 17th, these discussions will go on and then at that point, we would request all seriously interested parties to submit licensing applications which will be due on February 10th. At that point, we will evaluate the proposals internally and with a selection of partner or partners – depending on the types of applications that are submitted – by February 20th we'll notify those selected partners and we will negotiate term sheets with those individual partners. And from there on, we would develop draft licensing agreements, negotiate the specific license language, hopefully execute the license in a timely manner and then we will get to an NREL and Partner commitment to move this technology forward. Now, the one on one private conversations, these are the one on ones that were listed on that previous page that runs through January 17th. The purpose is for each company to present company specific information to us.

We realize that Q and A at the end of this particular seminar will likely not be appropriate for some of the questions that you probably have burning in the back of your minds right now but we also realize that you might have specific questions that you need to ask in order for you to internally evaluate this technology. So, you will have the opportunity to ask questions and get those questions answered, each in a 20 minute session with me. And if there are technology questions that I am unable to answer, then I can get those answers from Kirstin and her technical team as well. So, these are private discussions on the phone with me as licensing manager and please do realize that this is a non-confidential discussion. We do not want to waste time trying to get NDAs in place that we realize – on the NREL side as well as on the corporation side – that could be a time consuming exercise. It's not exercised and we'd like to get this opportunity out and commercialized as soon as possible.

So, these discussions, these one on ones will be non-confidential and in order to request a one on one meeting, please complete the survey that appears at the end of this live webinar. It's actually a scheduling tool which you will be able to access specific open appointment slots and request time slots that are convenient for you. Now, this survey is not a "How did you like this webinar" evaluation survey. It is a key next step in the commercialization process. Please don't just cancel out or ignore it.

Or you can also, alternatively, just visit the link. There is no need to contact me. All of my – I am committed to the time slots that are shown as available on the scheduling tool so I encourage you to take advantage of this opportunity because I believe this will be a real benefit to you as well as for, on my part, to be able to better evaluate the opportunity with you. Now, the license application which is due on or before February 10th , it's intended to be less than a business plan but a little bit more than a – __ term sheet. The templates are available at this web link shown.

There are a couple of different versions – one for small business, one for large business – and with these, if you do have specific questions regarding these templates, you are welcome to contact me on that at that point. And then the next step for us is to evaluate the impact. So, we look at benefits for NREL, the company, as well as taxpayers because we are operating the lab on behalf of the Department of Energy. So, we need to insure that it – that the license and the commercialization would benefit the company – you the company – as well as the taxpayers. So, in order to help the licensees to be successful, we are able to have the inventors available to help and cooperative research agreements or other partnership mechanisms in order to help you develop the technology.

However, the time is not unlimited. Kirstin and her team have other projects going on as well so we can only select a few licensees. And we are looking for partners who are serious about converting this technology from its current prototyping stage to manufacture and to result in an end product for sale. So, we request serious inquires only, please. Now, the license application is due on February 10th as noted earlier.

We set this deadline so that we can evaluate all of the offers at the same time so that we can identify the best options maximizing the benefits to the company, NREL and to the taxpayers. So, all offers are evaluated at the same time, insuring a strategic selection. Now the application – the content of this application, it helps me to perform the – our internal due diligence in evaluating the candidates. So, we request background about the company such as the product or service that you envision would embody this technology, the market size that you anticipate – current and potential – of your product with the addition of this technology. We'd like to understand your capabilities – on the technical side, the management team, marketing, financial as well as to communicate our requirements from NREL such as the assistance that you would need from NREL, such as would you require any special assistance from our innovators or use our equipment or facilities.

Now the appendixes to the licensing candidate information form – there are a number of them so let's – there are three key components. So, the key personnel resumes – that's for us to be able to evaluate your team and your team's capabilities and contacts, as well as a __ draft term sheet and a pro forma income form. Let's discuss first the tern sheet. So, the term sheet has to do with the types of terms that you would like – that you the company would be comfortable having in the license agreement itself. It would outline the basic offer; specify the type of license – such as exclusive or non-exclusive – proposed fees and royalties as well as to establish schedules and key milestones.

Now, regarding the basic offer, we would request your thoughts on the anticipated field of use, the period of time or a geographic area - those types of limitations that will help us evaluate your business plan going forward. So, the geographical area, for example, now might have to do with the eastern seaboard of the United States. We do envision – this is a globally applicable technology. So, that may not be a good example there. Also, to limit the – for us to understand the areas where you, the licensee, intends to market. And please, do highlight any significant terms or conditions that are significant for your company or your board.

Now, the type of license that we anticipate are exclusive, partially exclusive or non-exclusive and there are specific conditions associated with each one of these types. So, let's review them. The exclusive or partially exclusive license requires that whatever product that is intended to be sold in the United States must be substantially manufactured in the United States. This is a flow down of provisions from the Department of Energy to us in developing these technologies. So, that is a requirement.

An exclusive license does allow for the potential of sub-licensing if that is a part of your business plan. It also requires patent cost reimbursement for the related intellectual property. Now, the license agreement guidance is available online at this website and please do note that for exclusive licenses, we do expect higher fees and royalties for the benefits that are associated therewith. Now, a non-exclusive license is a little bit different in that there are no sub-licensing terms allowed in a non-exclusive license. However, there also is no US manufacturing requirement.

So, if you already have established manufacturing capabilities abroad, as long as – for non-exclusive licenses, that is not a requirement to – US manufacturing is not a requirement. And the patent cost reimbursement would be prorated with other non-exclusive licensees. So, we do anticipate the existence of multiple licensees for non-exclusive licenses. Now, regarding the proposed fees and royalties, there are basically the categories of upfront fees, patenting costs and running royalties. So, let's discuss each of these separately.

So, with an upfront fee – we do have fairly specific definitions for all of these. With an upfront fee, it is basically the signing fee for the license and we – it's generally required within 30 days after license execution. Patenting costs is another fee that would be charged within a license. Another one is running royalties. So, we do have a specific definition of running royalties calculated on net sales.

In general, licensees can specify the metric to be used in this net sales calculation. Given this particular technology, we would anticipate something in the terms of units such as the number of light bulbs sold, for example. Running royalties are paid at least annually, based on net sales, and I will – the definition is available in our license agreement template which I will share in a little bit. Please specify a preferred metric such as units. There is possibility of ascending or descending royalties’ structures depending on your business plan. That is a negotiable item.

There will also be minimum annual royalties. We recognize that these technologies that we have in our portfolio are at the prototyping stage and there will likely be a time period in which you're ramping up production, sales channels, those types of things. So, during that time when there may be small or little net sales, we require minimum annual royalty payment and these are basically to insure your due diligence in complying with the commercialization plans that you have in place. Now, for exclusive licenses, there are associated non-royalty sub-licensing payments. Basically, if you were to sub-license out to a third party, we would be collecting non-royalty sub-licensing payments such as – if you were to charge a signing fee to your third party licensee, then we would be requesting a part of that benefit as well.

Now, moving on to the term sheet. Now, the next item on the term sheet, we would establish schedules and key milestones for the – on your commercialization efforts. The specific types of schedules and key milestones events may be annual reports that will be tied normally with the minimum annual royalty payment or royalty calculations on an annual basis. Some other milestone examples are prototype demonstration, for example, followed by the development of your manufacturing capabilities. Funding or investments – particularly for startups, we may require a certain amount of investment for you to secure a certain amount of an investment as a milestone for the license.

Marketing efforts for the product may also be a milestone followed, of course, by the achievement of a certain level of sales by a certain period of time. Now, back to the application content. Let's talk a little bit more about the pro forma income form. There is a form provided. This is not an approved or appropriate accounting form.

It's not a true pro forma. However, now we're looking for ballpark numbers to better understand your anticipation of your commercialization efforts. So, we only request three years out only for the product line based on NREL's technology. And we would request including a royalty payments, a minimum, moving forward. So, this is not intended to request information on your entire RND budget but just a rough idea of RND associated with the products incorporated NREL technology.

The question that we're trying to answer is “What investment will you be making in order to bring that product to market?” We certainly don't want to encumber you with details. We don't want to know your entire costs structure – we realize that's sensitive business information. We just want a rough sense of the cost of product – although we do request that you be clear with your assumptions. The goal if for the royalty that's fair to NREL and allows you and your business to be successful as well.

We request submission in electronic format only and the template is provided in an Excel spreadsheet. So, as an example, this is a sample pro forma income statement. Please don't – these are fictional numbers that are on the template. Complete only the green shaded boxes. All the other values are calculated from your inputs.

State your assumptions very clearly so we can understand them. Please do separate market sectors or product applications if pricings vary. For example – if you're selling to different global sectors, then those numbers may be associated with different sales numbers and prices and we recognize that. Now, under the “Expenses” tab – under “Expense” category – these are just general terms. So, cost of goods are direct costs associated with the product.

SENA – please try to estimate all indirect costs. If it is easier for you, you are welcome to add any elements that make up our definition of net sales such as returns and brakeage. For RND, as stated earlier, please include only investment associated with this particular technology. For the royalty rates, please use the structure box in the top right corner as your starting point and then everything else will calculate based on that number. And as a reminder, this is basic info that we are looking for and you are welcome to modify.

We encourage you to use the Excel spreadsheet that is provided but then again, you are also welcome to modify. You don't need to project much beyond the three years and please do submit electronically. Now, most importantly, the evaluation criteria that we'll be using in order to evaluate these license applications have to do with your technical factors such as your understanding of the technology and challenges and technical capabilities and facilities to scale up and mature the product. There are also business factors such as your demonstrated company strength in this field of technology or product, relevant experience, _ financial condition of the company and the alignment of this – the NREL technology with other company goals and overall company mission and goals; clear identification of existing and potential customers; your characterization of the market – such as size, structure, trends/ your understanding of the barriers – any regulatory issues if applicable as well as estimate of penetration – and your own competitive advantage and position.

We also look at management factors such as the leadership team and high priority commitments of your management team – record of success of bringing similar products to market would also be very helpful; a demonstrated marketing capability to achieve marketing goals that you may set, a reasonable proposed effort – including time and resource estimate – and clear identification of milestones, payment minimums and tracking methods. Finally, there are economic factors as well such as the amount of royalty revenue that we are able to generate based on this license, the expected time to product launch – the sooner the better, of course, for everyone – impact on end users and benefits to taxpayers as well as expectations for export of the product such as your understanding of ___ compliance. And just to be up front – not all qualified companies will be granted a license. So, please do submit your best offer at this time.

Now, with the negotiation process, moving forward, we are looking for the win/win. So, the types of issues that are negotiable are types of license – we discussed the exclusive, the partial exclusive as well as non-exclusive. The field of use is also negotiable. Upfront licensing fee, the running royalty rate, yearly minimum and milestones are all negotiable terms. Now for non-negotiable terms we have a number of them as well.

NREL and the government of the United States retains irrevocable royalty free rights to use the technology for non-commercial uses. There are specific flow down provisions from NREL's prime contract with the US Department of Energy. There are Bayh-Dole requirements that are mandated by congress as well as certain terms related to ___ and warranty. Now, these details – specific details on these requirements can be found at this website here. This is the Department of Energy website that has the NREL prime contract and more information can be found there.

Now, with the *[Break in audio]* finally, upon – after the evaluation period, we'll send an email to you to let you know whether or not you have been selected as a licensee. The selected companies will be announced after signing and then we will move on to monitoring the commercialization to insure that the milestones are met, compliance with annual reporting requirements and payments and success points will be celebrated and publicized with the support of NREL public affairs. Now, that concludes the licensing discussion. Now, I want to talk a little bit about the other opportunities that are available here at NREL.

So, there are some related IP that may be of interest to you. We also have collaborative RND opportunities as well as the use of NREL labs and other facilities and our facilities – the Work For Others and also user facility opportunities. So, some other IP that's potentially relevant to the particular ___ – lighting market. We do have a different approach to the growth of mismatched, semiconductor layers on top of disparate substrates. So, another approach that we have that we call – that we refer to a growth of lattice matched semiconductor layers.

This particular technology is the subject of five different records of invention at the lab basically covering better matching the orientations of semiconductor materials in order to increase yield, reduce cost and make more efficient semiconductor devices. So, one particular application of this technology is the coincident __ lattice matching of indium on spinel substrates. I won't get too deep into the technologies here – just to say that slightly different from the graded buffer layer approach that Kirstin had discussed earlier, this one is talking about rotation of the crystalline layers of the semiconductor materials in order to achieve lattice matching and growth of disparate semiconductors that you would normally think would not be compatible due to the lattice mismatch. And we have achieved some technical prototyping of this particular technology. If you are interested in learning more about this technology, please do contact me and I can put you in touch with the appropriate technical team.

For this particular technology, they are looking for opportunities for future development. We do – we are looking for – an ideal collaborator would have the resources to do both material and device developments of this technology. Another related IP that we have has to do with multi junction solar cell PV device. This has to do with the isoelectronic co-doping of the semiconductor layers. Also, uses additional layers to bridge the gap between disparate size semiconductors to create highly efficient, multi-junction photable paths.

Specifically related to partnering with NREL, we welcome the opportunity to work with all of you. NREL pursues funding opportunities in partnership with commercial entities. We want to understand your needs so we can better asses our capabilities and how we at the laboratory should be focusing our technical efforts. For example, we do have capabilities for testing validation optimization and also a collaborative research. We just want to emphasize that we are broader than just today's future technology.

So, we would like you to look at NREL strategically and consider a long-term relationship with us. So, just a brief overview of the laboratory itself and other capabilities that we have. We are specifically focused on energy efficiency and renewable energy technology RND. So, we began as the Solar Energy Research Institute, so we started with solar. But we have expanded our scope towards other energy efficiency and newborn energy technology studies as well.

So, we have been in business for over 35 years. Our budget for fiscal year '13 – which ended in September – less $309 million. We have over 2,000 staff on site. We also have more than 350 active partnerships at this time. We are considered the international benchmark for sustainability.

Now, we have a wide scope of – our mission has a wide scope ranging from energy efficiency and renewable energy technologies to system integration and deployment of these energy efficiency technologies as well as to look at the market conditions. A brief overview – I'll go through these slides very quickly. So, we do have a portfolio of technologies related to photable __ as well as biofuels, energy generation and storage – such as in batteries. We do have a very large facility that specializes in wind technology. We have a portfolio of IP related to vehicles as well as buildings.

And finally, we have a – from the technology transfer office, we have the NREL Commercialization Assistance Program – or NCAP – which provides up to 40 hours of NREL assistance – researcher assistance – and information to help small businesses with specific technical challenges. These are intended to be well defined projects or hurdles that we're trying to help you clear within the confines of about a 40 hours project. Examples of NCAP assistance may include, for example, testing and measurements of specific systems or components, analytical testing or other types of small projects that may help you clear a hurdle that is in your business trajectory. Now, some other resources that are available for your consideration – there is a technology listing for this particular technology at this website here. Please do spend some time on our website to look at other capabilities that may be of interest to you regarding facilities, personnel, equipment – and that's available at www.NREL.gov.

And finally, I'd like to call your attention to the energy innovation portal, which is a collaboration among several of the Department of Energy labs as well as some universities and other institutions. So, there are over 17,000 patents listed and growing from all of the DOE labs and they're also 850 plus marketing summaries that are – that basically summarize the commercialization opportunity for certain portfolio families for business evaluation and that is available at techportal.eere.energy.gov. So, to summarize the next step, please do schedule your one on one meeting to speak with me. You can do that by completing the post webinar form or visiting the scheduling tool. Please do download the guidance and forms that are available at these websites and we will move on to question and answers.

Devin Egan: Laura, do you have questions available?

Laura Schoppe: Yes we do. We have quite a few. Why don't we start off with some of the technical questions? First technical question is – what's the typical process that NREL follows to test and validate their new game-changing technology? How are you sure that this technology works?

Kristin Alberi: So we – as I mentioned earlier, we've created prototype devices. All of our measurements are not absolute EQEs but I went into a very specific description of how we've extrapolated EQEs and, moving forward of course, we expect to refine our prototypes to actually get specific EQEs of these devices.

Laura Schoppe: Okay. If you mentioned it, could you repeat what substrate this technology uses?

Kristin Alberi: Yes. It's grown on a gallium arsenide substrate.

Laura Schoppe: Okay. Great. And will this technology address California Energy Commission Color Rendering Index specifications for utility rebates?

Kristin Alberi: Yeah. So, the whole idea of the amber LED is to improve the color rendering index or RGB or RGBA color mixing white LEDs. So, this is expected to add a critical component to those devices.

Laura Schoppe: Okay. And how does the theoretical efficiency of this technology compare with the efficiency of phosphor converted amber LEDs on the market today?

Kristin Alberi: So, I don't have exactly specific numbers for you but the efficiencies are supposed to be higher than phosphor converted LEDs specifically because they eliminate the Stokes shift loss.

Laura Schoppe: Okay. And what happens if you dim these – if you created a light from this technology, what would happen if you dim it? Is it a dimmable technology?

Kristin Alberi: Yeah. We're working to make these technologies dimmable.

Laura Schoppe: Will the light be warmer as you dim it?

Kristin Alberi: So, that would all have to do with how you change the drive of these different LED components within the color mixing architecture. And so I imagine that that – that would be an option for you at some point.

Laura Schoppe: Okay. So, while we're talking about comparing it with current or conventional LED lighting, can you tell us a little bit more about how it compares for energy consumption, life of the light bulb, the quality of the light as well as cost?

Kristin Alberi: So, those are a lot of metrics. In terms of quality of the light, it should be much better because at some point, we could imagine, say, changing a different components of how much light is emitted from each one of these LEDs. And so you would have some sort of dynamic color control that would allow you to specifically tune the color of the light which – I'm sorry – what are the other?

Laura Schoppe: The light bulb.

Kristin Alberi: I'll take one at a time. Yeah, so the life of the light bulb would at least be similar to phosphor converted LEDs, if not, maybe better as the LED component is expected to have a very long lifetime.

Laura Schoppe: And what about the cost? If you were to implement this in production, is the cost reduced? Is it higher? How does it compare with current manufacturing?

Kristin Alberi: So, the cost of LED light bulbs are kind of in flux right now as these technologies get a wider market acceptance. So, I would expect it to cost maybe a little bit more out of the gate but then also kind of move into parity, at least, with the phosphor converted design.

Laura Schoppe: Okay. And what about the energy savings?

Kristin Alberi: So, higher efficiency light bulbs would mean more energy savings.

Laura Schoppe: And any idea as to what that would be over a 10 year period?

Kristin Alberi: So, I don't have very specific numbers for you but the types of numbers that we're looking at can be found on the DOE EERE solid state lighting website.

Laura Schoppe: Can you repeat that URL please?

Kristin Alberi: I don't have the specific URL but if you look up the – yeah, the solid state lighting program within the energy efficiency and renewable energy office, they will have more information there.

Laura Schoppe: All right. We'll try to get that and send that out as part of the email. Okay. Is NREL continuing to develop this as well as other related LED innovations?

Kristin Alberi: Yeah, absolutely. As you know, we kind of learn more from basic science all the way thorough applied science. We're continually improving these types of technologies.

Laura Schoppe: And will that be available for licensing?

Kristin Alberi: Yeah, I suspect so, as they start to come online.

Laura Schoppe: Okay. I'm gonna move now more into some of the licensing questions. Now, you mentioned that for exclusive licensing, you have to have US manufacturing. Are there any other requirements in order to qualify for an exclusive license?

Yoriko Morita: So, we do have – the burden of due diligence becomes higher because with an exclusive license, what we're essentially doing is putting our – the taxpayers' eggs into one basket. So, it would be – we would be taking a higher risk at the lab in order to exclusive license – exclusively license a technology to a particular company. So, we would request higher commitment in terms of possibly more stringent milestones requirements. But those things, of course, are negotiable as well. So, other than the US manufacturing – which tends to be a large hurdle for a lot of our exclusive licensees – our potential exclusive licensees – other requirements can be found on the website that I referenced earlier.

Laura Schoppe: Okay. And you had also mentioned that there would be higher fees. Is there a typical how much higher you have expectations for an exclusive licensee?

Yoriko Morita: No, you know, we look at the overall expected market numbers at that point. So, that's where the pro forma comes in to play in that we do evaluate the royalty revenues based on our own expectations of the market growth as well as the corporate capabilities. So, we would base that number on how large the field of use, for example. If you're looking for an exclusive license globally, that would – that – the royalty requirements for that – especially since we're talking about a potentially $36 billion market by 2018 – we would be adding one or two zeroes, I would assume.

Laura Schoppe: Okay. Again, I encourage everybody – if they have questions, to type them into the question section of the panel and I'll continue to ask the questions that have already been submitted. You had also mentioned on part of the calculation for what would be acceptable licensing revenue that patenting costs are part of it. Can you provide any information on how much has been expended on patenting costs to date and are there any typical upfront or running royalty rates that you can share?

Yoriko Morita: So, if you look at – if you're referring to the one slide that we had with our IP listed on it – so we have two US applications as well as a number of international applications, I believe, in Canada, Europe and Japan and with those applications, our patenting costs are in general alignment with what you would normally expect from patent prosecution in those countries. You can ask your IP – your relevant IP professional for those estimated numbers but the general ballpark is that we have done the initial filings for all of these applications, the current ballpark that I'm usually given by IP people is for European patent applications, for example, over the course of prosecution, we're looking at costs on the order of $50,000.00 to $60,000.00. In Japan, that might double because of translation and also, for Europe, once the prosecution – once the European prosecution has been completed, in order to be able to enforce your patent in a variety of the EU countries, you do have to pay issue fees at those different countries as well. So, depending on your intended market, those are costs that you can also request estimates from your legal professional as well.

Laura Schoppe: Okay. There was a similar question of – can licensing be used in other countries. You just addressed that you have two US patent applications, Canada, Europe and Japan. Are there other countries that you have current coverage in or if this company is interested using the technology in a country that you have not yet pursued patent coverage, would you expand patent coverage to include it?

Yoriko Morita: So, we're actually outside of the window of being able to expand to other countries. However, you know, any new innovations that may come out of further development of this technology, we would consider filing internationally. And usually, with international applications, we do rely on our corporate partners. So, the companies that we are working with in order to develop the technology to give us guidance as far as specifically which countries they would like us to file. And then, of course, we would get into a cost share – a sharing of those patent costs at that point.

Laura Schoppe: And are the both of those patent applications, as well as the European or the foreign application – are those available on that website you provided for download?

Yoriko Morita: Yes, they are available, I believe, on the LED technology website as well as from – if not, we'll make it available. Otherwise, you can also search for them as well. They're available publically on just public websites.

Laura Schoppe: Okay. And is any financing available as part of this joint – as part of licensing?

Yoriko Morita: Unfortunately, we are not a financing institution so we would not be able to provide financing. But if – we have heard from previous – from our existing licensees that having a license from NREL has *[Break in audio]* in obtaining other financing because it shows that there is a level of commitment to developing a particular technology with a significant advantage that helps that company to raise future money.

Laura Schoppe: Okay. And during the one on one calls, will it be possible to ask specific questions about the offers that we may have such as royalty rates? And will you give feedback on that?

Yoriko Morita: I would *[Break in audio]* So, I guess my interpretation of that question is "Would you be able to get an idea of what other competitors are proposing as royalty rates?" The answer will be "No." However, I can probably guide you towards ballpark of what we would be looking for, knowing what we know about the market potential for this technology.

Laura Schoppe: Actually, I think the question was if the company said, “This is what we're interested in proposing” would you be able to provide a reaction to that verbally?

Yoriko Morita: Yes. That I can.

Laura Schoppe: Okay. I don't have any more questions that are popping up. If anybody else on the webinar has a question, now is your time to ask before we wrap this up. We've got just a few minutes left. All right.

I have not received any more questions but I would reiterate the fact that Yoriko will be conducting one on one sessions so if you do have company specific or additional questions, that will be your opportunity to ask them. And the survey will point you in that direction. So, I will hand this back to you Devin and Yoriko.

Devin Egan: Great. I think we're done then and thank you everyone for attending and please don't forget to fill out the survey or set up a time to meet with Yoriko.

Yoriko Morita: Thank you very much for your attention. I look forward to your feedback.

Kristin Alberi: Thank you.

Yoriko Morita: Bye bye.